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# Monitoring Raccoon Rabies in Alabama: The Potential Effects of Habitat and Demographics

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# MONITORING RACCOON RABIES IN ALABAMA: THE POTENTIAL EFFECTS OF HABITAT AND DEMOGRAPHICS

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***Abstract:*** Density, morphometrics, and disease prevalence of raccoon populations were determined in 4 habitats (agriculture, riverine, managed, and forested) in central Alabama. In addition we monitored 71 collared raccoons to determine survival. Density estimates were similar in the agriculture (ag) and riverine habitats in central Alabama with 8 raccoons/km$^2$, and lower in the forested habitat at 5 raccoons/ km$^2$. Retention of juveniles did not appear to contribute to observed higher populations in the riverine and ag habitat. Although the riverine and ag, possibly due to supplemental resources, likely provide better habitat for raccoons, we found only body size in female raccoons to be different across habitats ($P$ = 0.001). Human-caused mortality (either hunting or missing and presumed killed) was the main cause of mortality in several raccoon populations during fall; however, fall survival did not differ between the habitats ($\chi$ = 1.47, d.f. = 3, $P$ = 0.69). Although rabies and distemper virus were prevalent in all habitats, they did not appear to contribute to mortality even with a high proportion of the population exhibiting positive CDV titers (ag – 44%, managed- 50%) and rabies titers (managed- 57% and riverine habitat-60%).

***Key words:*** density, distemper, habitat, hunting, rabies, raccoon, survival

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## INTRODUCTION

Raccoons are ecological generalists who have successfully expanded their range across much of North America. However, while there have been extensive studies on raccoon ecology in the northern and midwestern areas of their range (Johnson 1970, Urban 1970, Fritzell 1978, Gehrt et al. 1990, Gehrt and Fritzell 1997, Gehrt et al. 2002, Kamler and Gibson 2003, Prange et al. 2004), little focus has been placed on gaining similar biological information from the southeastern portion of North America in the past 30 years. Recent data regarding differences in raccoon population size, adult survival, and disease prevalence is lacking on southern populations. As raccoon populations continue to increase throughout the rest of their range in the United States (Gehrt et al. 2002), challenges to resource managers and potential threats to public health are imminent without increased biological knowledge of this species.

Regarded as an important, common and widely-distributed furbearer, raccoons have historically been harvested for their pelts (Chamberlain and Leopold 2001). During the mid-1900s, hunt clubs commonly stocked raccoons on their property (Nelson 1955): often these stocked animals were relocated from alternate areas. The 1970s mid-Atlantic rabies outbreak was attributed to the translocation by humans of infected raccoons from the southeast (Jenkins et al. 1988). Raccoon hunting and trapping remain an important tradition in the southeast, providing sport, income and food, and harvest estimates in Alabama since the 1960s have fluctuated between 49,000 and 230,000 animals per year. Chamberlain et al. (1999) examined survival and cause-specific mortality in Mississippi, in order to determine the effects of an additional hunting season on the local populations, yet there is a lack of recent publications on raccoon survival and mortality in the southeast (Cunningham 1962, Caldwell 1963, Johnson 1970, Fleming 1975).

Management of southeastern raccoons, as well as a better understanding of disease transmission among wildlife, humans, and domestic animals, relies on current survival and mortality estimates. Although canine distemper is thought to play a major role in regulating raccoon populations (Johnson 1970), Kappus et al. (1970) reported raccoon rabies was an important mortality factor in the southeastern United States. In 1999, 2,872 reported cases of raccoon rabies occurred in the U.S. Rabies spread into Alabama over 30 years ago, but has not continued to spread westward at a rate commensurate with the northward spread up the Atlantic seaboard and the subsequent westward spread through states in the north. Illegal translocation and raccoon stocking could still occur, presenting the threat of further disease transmission and added complication to species management. Our specific objectives were to determine: 1) raccoon densities in bottomland hardwood, managed, agriculture, and forested habitats; 2) survivorship of adult raccoons in various habitats and the leading contributors to mortality; 3) the potential effects of anthropogenic resources on raccoon morphometrics and survival; 4) prevalence of rabies and distemper in the 4 habitats.

## STUDY AREAS

Research was conducted on three study sites in central Alabama and one site in west-central Alabama. The first site is in the Lowndes County Wildlife Management Area (WMA), located in northern Lowndes County, near the township of White Hall, and is managed by the Division of Wildlife and Freshwater Fisheries of the Alabama Department of Conservation and Natural Resources. Covering 4,100 hectares, the Lowndes WMA is primarily composed of mature hardwood forests, consisting of various oaks (*Quercus* spp.), red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), American beech (*Fagus grandifolia*) and hickories (*Carya* spp.), and pine forests. The core study area in this WMA covers approximately 748 forested hectares and is bordered to the north by the Alabama River, to the east by Cypress Creek, to the south by Lowndes County Road 40 and to the west by House Creek. This area includes Holy Ground Battlefield Park and is covered principally (~75%) by mature bottomland hardwoods (riverine habitat). Lowndes WMA is available to the public for hunting and fishing in regulated seasons, picnicking, and additional recreational activities.

The second study area is composed of privately owned agricultural land in Lowndes County, near the township of St. Clair. It covers approximately 1,180 hectares and is 60% pasture for cattle farming. The remaining land is comprised of fence rows, hardwood forest patches, ponds, streams, and man-made structures, including several chicken houses and storage buildings. Hungting raccoons at night is allowed in both Lowndes County study sites from 6 September through 28 February.

The third study area is in the Autauga Community Hunting Area, located in Autauga County, north of the city of Prattville and the Alabama river. Managed by the Division of Wildlife and Freshwater Fisheries of the Alabama Department of Conservation and Natural Resources, this area is available to the public for hunting in regulated seasons. The entire hunting area encompasses 2,638 hectares, approximately 1,600 of which are found in the core study area. International Paper owns the hunting area property, which is leased to the State of Alabama for wildlife management purposes. The primary vegetation on the Autauga hunting area is long-leaf pine (*Pinus palustris*) and loblolly (*P. taeda*) forests, planted for timber harvest (~80%). The pine stands are intersected with streamside management zones and planted food plots used to attract game species during various hunting seasons. In addition to planted food plots, management on the Autauga Community Hunting Area includes prescribed burning and herbicide application (managed habitat). Raccoon hunting season in the management area ranges from 1 September through 28 February.

The western study site is located in Hale and Bibb counties on the central-western edge of Alabama just south of Tuscaloosa. Oakmulgee WMA includes approximately 14,960 hectares in the Talladega National Forest. The terrain includes swamps, valleys, creeks, and a federal camp ground open to the public with a 39 hectare lake. This area is an active breeding site for the red-cockaded woodpecker (*Picoides borealis*) and management includes year-round prescribed burning in the long-leaf pine habitats. This region is also characterized by elevation changes with hardwoods dominating lowlands and conifers dominating the ridges. Secondary and tertiary creeks are common in the lowlands often leading to swamplands. Forest composition consists of approximately 50% hardwoods and 50% pines, mostly long-leaf pine. Raccoon hunting is permitted from 1 October to 28 February.

## METHODS

Raccoons were live-captured in single door box traps (Tomahawk Live Trap, Tomahawk, Wisconsin) baited with sardines during spring and fall of 2004. Traps were deployed in late morning or early afternoon and checked daily, in the early morning. Raccoons were immobilized with ketamine hydrochloride and xylazine (5:1 ratio), injected with a hand-held syringe, intra-muscularly. Once immobilized, ophthalmic ointment was placed in the animals' eyes, to prevent the eyes from drying out, as the blinking reflex is halted by the immobilizing drugs. Animals were weighed, sexed and ear tagged (Monel #3, National Band and Tag Company, Newport, Kentucky). Skull length, body length, tail length, and hind-foot length was measured. An AVID® microchip (American Veterinary Identification Devices, Norco, CA) was inserted subcutaneously for additional identification measures and a lower premolar was extracted for age determination. In addition, 5cc of blood was drawn to test for the prevalence of rabies by the Centers for Disease Control (CDC) and canine distemper (CDV) titers by Cornell University Animal Health Diagnostic Laboratory. Blood was collected from the jugular vein after shaving the area with electric clippers and cleaning the area with rubbing alcohol. Skin abrasions and cuts inflicted on the animal during the trapping and handling period were cleaned and treated with a topical antibiotic ointment.

In each of the four study areas, approximately 10-15 adult raccoons were fitted with mortality-sensor VHF transmitters (Advanced Telemetry Systems, Inc., Isanti, MN and Telemetry Solutions, Walnut Creek, CA). We attempted to maintain at least five adult raccoons fitted with GPS-Posrec™ transmitters (Telemetry Solutions, Walnut Creek, CA) in each of the study areas. Adult status was determined at the time of capture by body size, tooth wear and teat size/pigmentation for females (Sanderson 1961, Grau et al. 1970). GPS-Posrec™ units are self-releasing and are programmed to drop off when on low-battery. These collars also include an external VHF antenna and were programmed to broadcast on Tuesday and Thursdays of each week. The VHF signal also facilitates recovery when the collar drops off. The collar acquires satellite positions on raccoon locations throughout the remainder of the week, during the programmed time. Raccoons were monitored until recovery and released at the point of capture.

Radio-collared animals were located $\geq$ 3 times a week using a hand-held 3-element directional Yagi. We monitored animals throughout a 24-hour period with at least 2 hours in between consecutive locations. Raccoon locations were triangulated using the LOCATE (Pacer, Truro, Nova Scotia) software package with $\geq$ 2 bearings taken < 10 minutes apart. To minimize triangulation error, bearing angles were maintained between 20° and 160° (Gese et al. 1988). Sequential locations, obtained at least twice a week, were run on a 12-hour basis, with a location on each raccoon recorded every two hours. In addition, monthly attempts were made during the daytime to track animals to their resting and/or nest sites.

We monitored radioed raccoons to determine causes of mortality. Probable cause of mortality was determined by examining the carcass for external and internal injuries, puncture wounds, and hemorrhaging. Physical evidence at the site of mortality such as tracks, scat, or hair also assisted in determining the possible cause of death. A Kaplan-Meier survival analysis was performed annually (2004) and for fall (October – December) to compare survivability distribution functions among habitats using the Wilcoxon test of equality (SAS® Version 8.0, SAS institute Inc., Cary, N.C.).

To estimate populations, trapping sessions were conducted in October-November in the riverine and forested habitats. Density studies lasted for 10 nights, using a 50-trap grid spread along a 3 $km^2$ area and were conducted according to the national Oral Rabies Vaccination (ORV) program protocol (Slate, unpublished data), with the goal of capturing all unique raccoons in the grid area. A smaller scale density study was conducted on the agriculture site using 50-trap grid (1.5 $km^2$) for 5 nights. We compared raccoon morphometrics (weight, body size, and hind foot length) between habitat using an ANOVA with a least significant difference test for multiple comparisons to test means between habitats (SAS® Version 8.0, SAS institute Inc., Cary, N.C.). A Chi-square contingency table was used to compare proportion of adults versus juveniles captured during the density study.

All animal care and use for this study was approved by NWRC's Institutional Animal Care and Use Committee, protocol number 1105 and Auburn University's Animal Care and Use Committee.

## RESULTS

We captured 120 unique raccoons in 2004 from the 4 habitats (Table 1). Seventy-two percent of the captures were adults and sex ratios overall were close to 1:1. More males were captured in the forested site most likely due to the initial trapping period that occurred in May when females moved infrequently due to denning. Density estimates were similar in the agriculture (ag) and riverine habitats in central Alabama with 8 raccoons/km$^2$. Densities were lower in the forested habitat at 5 raccoons/ km$^2$. We found no difference in proportion of adult to juveniles between the three habitats where density estimates were taken ($\chi^2$ = 1.51, d.f. =2, $P$ = 0.45). Male raccoon morphometrics (i.e. weight, body size, and hind-foot length) did not differ significantly between the habitats (Table 2); however, males inhabiting the forested area tended to be smaller than raccoons in the other 3 habitats ($P$ = 0.08). Female raccoons in the ag habitat were larger than females in the other 3 habitats ($P$ = 0.001), but body size and hind-foot length were similar across habitats (Table 3).

**Table 1. Raccoon captures in central and western Alabama, 2004.**

| Habitat | Sex | Total capture | Adults | Subadults | Total collared |
|---|---|---|---|---|---|
| **Riverine** | | | | | |
| | Male | 17 | 13 | 4 | 7 |
| | Female | 15 | 11 | 4 | 6 |
| **Managed** | | | | | |
| | Males | 10 | 10 | 0 | 8 |
| | Female | 11 | 11 | 0 | 6 |
| **Agriculture** | | | | | |
| | Male | 8 | 8 | 0 | 5 |
| | Female | 11 | 8 | 3 | 8 |
| **Forested** | | | | | |
| | Male | 29 | 20 | 9 | 19 |
| | Female | 19 | 15 | 4 | 12 |
| **Totals** | | 120 | 86 | 24 | 71 |

**Table 2. Male raccoon morphometrics in four habitats in central Alabama.**

| Habitat | Sample size | Weight | Body length | Hind-foot length |
|---|---|---|---|---|
| Pine forest | 20 | 3.94 ± 0.67[a] | 52.89 ± 3.02 | 10.18 ± 0.6 |
| Bottomland hardwood forest | 13 | 4.55 ± 0.97 | 51.47 ± 5.97 | 10.15 ± 0.5 |
| Agriculture | 8 | 4.55 ± 0.55 | 54.66 ± 2.17 | 10.18 ± 0.69 |
| Managed | 10 | 4.68 ± 1.15 | 52.66 ± 6.1 | 10.17 ± 0.49 |

[a] mean ± S.D.

**Table 3. Female raccoon morphometrics in four habitats in central Alabama.**

| Habitat | Sample size | Weight | Body length | Hind-foot length |
|---|---|---|---|---|
| Pine forest | 15 | 3.24 ± 0.33[a] | 50.06 ± 4.02 | 10.01 ± 1.28 |
| Bottomland hardwood forest | 11 | 3.27 ± 0.31 | 48.95 ± 1.83 | 9.47 ± 0.41 |
| Agriculture | 8 | 4.23 ± 0.44* | 51.3 ± 2.87 | 10.16 ± 0.73 |
| Managed | 11 | 3.28 ± 0.95 | 49.05 ± 4.26 | 9.6 ± 0.54 |

[a] mean ± S.D.

*significant at $P < 0.001$

Of the 71 radio-collared raccoons, 4 died during 2004 and 7 are missing. We considered animals that disappeared for ≥ 2 months, and were not located with telemetry flights, as dead for survival analyses. Collared raccoon sample size was too small to test annual survivorship by sex; annual survival did not differ between habitats ($\chi^2$ = 0.54, d.f. = 3, $P$ = 0.91). Although several animals went missing or were killed by hunters in the forested area ($n$ = 5), fall survival did not differ between the habitats (Figure 1: $\chi^2$ = 1.47, d.f. = 3, $P$ = 0.69). One female in the forest site was killed by a hunter in December and 5 males went missing in the fall of 2004 most likely from hunting. Two males in the riverine study area also went missing in the late fall. Female C5104 died in November in the raiverine habitat but was too decomposed to determine cause of death. C6304's collar went on mortality in July in the ag habitat but we could not retrieve her collar in a large snag.

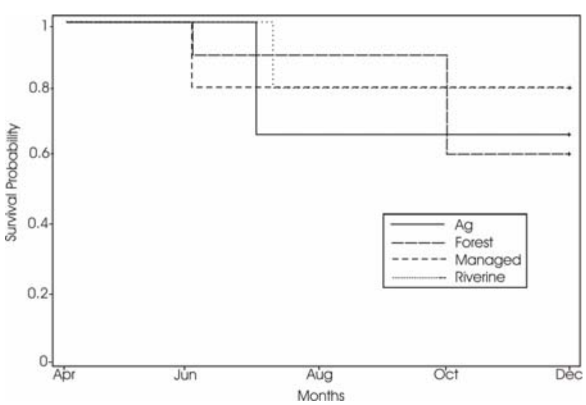


**Figure 1. Annual survival curves for radio-collared raccoons in four habitats within central Alabama, 2004.**

Blood samples for distemper were analyzed from 97 raccoons: 38 forested, 16 ag, 12 managed, and 31 riverine. A positive test result at a dilution means that antibody to CDV was detected up to that dilution, but no higher. One serum sample in the ag study area and 4 in the forested habitat contained a substance that kills the test cells, and there is no way to assess whether the virus was neutralized or not. These samples were considered positive, but the titers could be at either of 2 dilutions below where the cells were neutralized. We assumed the dilution below the reported negative value was positive following protocol from Cornell University Animal Health Diagnostic Laboratory. Habitats in closer contact with humans had a higher proportion of CDV positive titers (ag – 44%, managed 50%) than those areas less frequented by humans (forested – 23%), with the exception of the riverine habitat (24%). Positive antibody titers for adults ranged from 1:8 or 1:12 to 1:512, in the central portion of Alabama, and were slightly lower towards the west in the forested habitat where positive titers ranged from 1:8 to 1:24 (Figure 2).

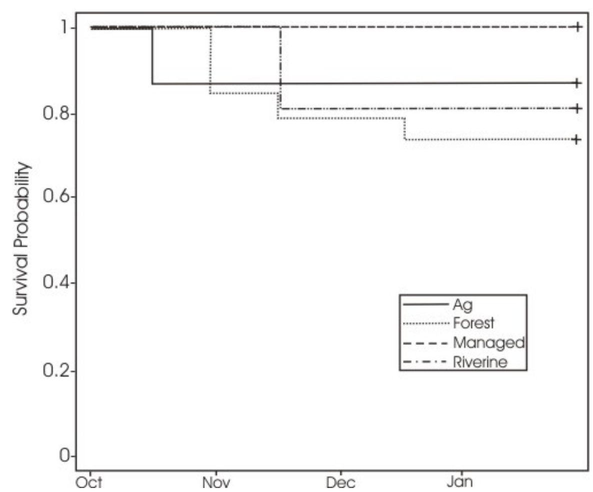


**Figure 2. Fall survival curves for radio-collared raccoons in four habitats within central Alabama, 2004.**

Laboratory analysis for rabies antibodies was completed on serum samples from 43 raccoons: 6 ag, 11 managed, 8 riverine, and 18 forested. The central portion of Alabama is considered the rabies enzootic area and contains the ag and riverine habitat south of the Alabama river and the managed habitat north of the river.

Proportion of positive rabies titers (>0.5) were higher in the managed and riverine habitat where 57% and 60% respectively of the animals tested positive. In both the forested and ag habitat only 20% of the animals showed positive titers.

**DISCUSSION**

Bottomland deciduous habitats or habitats with aquatic association are thought to sustain the highest densities of raccoons in the southeast because of water availability, den sites, and mast production (Lotze and Anderson 1979, Minser and Pelton 1982, Leberg and Kennedy 1988).

In addition, supplemental food resources (ie. anthropogenic sources) and supplemental den sites are thought to be factors that contribute to increased raccoon densities (Hoffman and Gottschang 1977, Prange et al. 2003). Raccoon densities in rural, harvested areas vary widely, 0.9 – 27.0 animals/ $km^2$ (Riley et al. 1998). The bottomland deciduous habitat located around the riverine are in Lowndes County contained a higher density of raccoons (8 animals/$km^2$) than the forested habitat in west-central Alabama, but not nearly the magnitude of animals reported in other rural hunted habitats. Natural food resources as well as the potential of anthropogenic influences likely contribute to the higher densities in this area as well as in the ag habitat. This is additionally supported by the larger raccoons documented in these habitats compared to the forested site.

Supplemental food may also allow for increased survival rates (Riley et al. 1998) and retention of juveniles (Prange et al. 2003). We found no difference in proportion of juveniles to adults to suggest retention of juveniles due to increased habitat quality from the central to the western sites. However, these are preliminary results and may have been observations prior to dispersal of juveniles. In addition, survivorship was high in all study areas; however, the forest habitat appeared to be more impacted by hunting pressure than the other two areas. Our findings are similar to other studies where in harvested areas, human-caused mortality is the leading factor (Johnson 1970, Clark et al. 1989) and natural mortality has little effect on the population (Clark and Fritzell 1992).

Distemper is an important disease that can regulate populations (Schubert et al. 1998), and even have negative impacts on populations such as the case with the black-footed ferret (*Mustel nigripes*)(Thorne and Williams 1988). Diseases transmitted by contact, such as CDV and rabies can negatively impact a dense raccoon population as well as be maintained for longer periods with increased animal numbers (Riley et al. 1998). Increased contact during breeding and gestation periods often produces an increased incident of canine distemper (Roscoe 1993, Chamberlain et al. 1999). CDV can lead to high incidence of mortality and significantly impacts raccoon populations (Riley et al. 1998, Mitchell et al. 1999) and some suggest a 4-year cyclic nature of the disease (Hoff et al. 1974, Roscoe 1993). The forested area, a less dense raccoon population, contained proportionally fewer animals with seropositive results for distemper then the denser raccoon site in the ag habitat. Although both the ag and riverine habitat were close spatially and both were in close proximity to human habitation; the ag habitat had almost twice as many positive animals as the riverine habitat. Our results from the ag and managed habitat are similar to other epizootic areas: Florida, 54% (Hoff et al. 1974) and Ontario, 49% (Schubert et al. 1998). However, even with the high prevalence of distemper in these two habitats, there appears to be little effect on survivorship thus far.

Of the three habitats within central Alabama rabies enzootic area (ag, riverine, and managed), only two had significant positive titers (> 50% of the animals tested). The ag habitat located on the south side of the Alabama river near the riverine habitat contained a third less positive cases. Densities were similar between the ag and riverine habitat, yet the high density in the ag habitat does not appear to have assisted in the spread of rabies. Although the forested habitat is currently managed outside the rabies enzootic area, it appears that rabies is spreading westward with 20% of the raccoons testing positive. Positive cases between the enzootic area and the western site are very limited; however, there have been no outbreaks. We therefore think it likely that the occurrence of rabies in the western study site may be due to translocation of infected raccoons.

Density of raccoons in central Alabama appears to be higher in those preferred habitats (bottomland hardwoods and aquatic areas as well as areas with supplemental food) even with the presence of both rabies and distemper. Although densities are higher than in the non-preferred pine forest habitat, retention of juveniles appears not to influence the population. This study, however, represents a picture of a narrow window of time representing only those kits that survived and left the nest. We are unsure of how reproductive success might differ between habitats and how additional anthropogenic sources and the prevalence of disease might influence reproductive success and kit survival prior to dispersal.

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